

Claims

1. Apparatus for providing optical radiation having a signal wavelength, which apparatus comprises at least one pump for providing pump radiation, a gain medium, and energy limiting means, in which the pump radiation acts on the gain medium to provide stored energy and gain for optical amplification, characterised in that the gain has a maximum gain at a wavelength at which the maximum gain occurs, and the energy limiting means limits the maximum gain and the amount of stored energy that is able to be stored to values below those at which the stored energy will cause damage to the apparatus.

2. Apparatus according to claim 1 in which the gain medium is such that the signal wavelength and the wavelength at which the maximum gain occurs are separated by less than 10nm.

3. Apparatus according to claim 1 in which the gain medium is such that the signal wavelength and the wavelength at which the maximum gain occurs are separated by at least 10nm.

4. Apparatus according to any one of claims 1 to 3 in which the energy limiting means comprises first and second reflectors characterised by first and second reflectivities and an energy limiting wavelength, the first and second reflectors forming a cavity about the gain medium, and the first and second reflectors being such that they limit the available gain when the gain medium is pumped by the pump such that the stored energy is unable to cause damage to the apparatus.

5. Apparatus according to claim 4 in which the first reflectivity is greater than the second reflectivity.

6. Apparatus according to claim 4 in which the first reflectivity is the same as the second reflectivity.

7. Apparatus according to claim 4 in which the first reflectivity is less than the second reflectivity.

1 8. Apparatus according to any one of claims 4 to 7 in which at least one of
2 the first and second reflectors is designed to reflect at least 0.01% of optical radiation
3 at the energy limiting wavelength.
4

5 9. Apparatus according to any one of claims 4 to 7 in which the product of
6 the first and second reflectivities is substantially equal to the reciprocal of twice the
7 small signal gain at the energy limiting wavelength.
8

9 10. Apparatus according to claim 9 in which the gain medium is pumped by
10 at least 1W of the pump radiation, and the maximum gain is less than 40dB.
11

12 11. Apparatus according to claim 10 in which the gain medium is pumped
13 by at least 10W of the pump radiation, and the maximum gain is less than 30dB.
14

15 12. Apparatus according to claim 11 in which the gain medium is pumped
16 by at least 100W of the pump radiation, and maximum gain is less than 25dB.
17

18 13. Apparatus according to claim 12 in which the gain medium is pumped
19 by at least 1000W of the pump radiation, and the maximum gain is less than 20dB.
20

21 14. Apparatus according to any one of claims 1 to 3 in which the gain
22 medium is pumped by the pump radiation at a pump power of at least 1W, and in
23 which the energy limiting means comprises an optical source that provides at an
24 energy limiting wavelength an energy limiting power greater than 40dB relative to
25 the pump power, which energy limiting power acts on the gain medium to reduce the
26 amount of stored energy and gain when the gain medium is pumped by the pump
27 such that the stored energy is unable to cause damage to the apparatus.
28

29 15. Apparatus according to claim 14 in which the gain medium is pumped
30 by at least 10W of the pump power, and the energy limiting source provides an
31 energy limiting power greater than 30dB relative to the pump power.
32

1 16. Apparatus according to claim 15 in which the gain medium is pumped
2 by at least 100W of the pump power, and the energy limiting source provides an
3 energy limiting power greater than 25dB relative to the pump power.
4

5 17. Apparatus according to claim 16 in which the gain medium is pumped
6 by at least 1000W of the pump power, and the energy limiting source provides an
7 energy limiting power greater than 20dB relative to the pump power.
8

9 18. Apparatus according to any one of claims 4 to 17 in which the energy
10 limiting wavelength is in the same emission band as the signal wavelength.
11

12 19. Apparatus according to any one of claims 4 to 17 in which the energy
13 limiting wavelength is in a different emission band from the signal wavelength.
14

15 20. Apparatus according to claim 18 or claim 19 in which the energy
16 limiting wavelength is greater than the signal wavelength.
17

18 21. Apparatus according to claim 18 or claim 19 in which the energy
19 limiting wavelength is less than the signal wavelength.
20

21 22. Apparatus according to claim 20 or claim 21 in which the energy
22 limiting wavelength and the wavelength at which the maximum gain occurs are
23 separated by less than 10nm.
24

25 23. Apparatus according to claim 20 or claim 21 in which the energy
26 limiting wavelength and the wavelength at which the maximum gain occurs are
27 separated by at least 10nm.
28

29 24. Apparatus according to any one of the preceding claims in which the
30 optical radiation is coupled to a scanner.
31

32 25. Apparatus according to claim 24 and including a controller for
33 synchronizing the optical radiation with the scanner.

1 26. Apparatus according to any one of the preceding claims in which the
2 gain medium forms part of an optical fibre.

3
4 27. Apparatus according to claim 26 in which the optical fibre comprises
5 rare-earth dopant.

6
7 28. Apparatus according to claim 27 in which the optical fibre is a cladding
8 pumped optical fibre comprising a core, an inner cladding for guiding pump radiation
9 supplied by the pump, and an outer cladding, and in which the rare earth dopant is
10 disposed in at least one of the core and the inner cladding.

11
12 29. Apparatus according to claim 27 or claim 28 in which the rare-earth
13 dopant is selected from the group comprising Ytterbium, Erbium, Neodymium,
14 Praseodymium, Thulium, Samarium, Holmium and Dysprosium, Erbium codoped
15 with Ytterbium, or Neodymium codoped with Ytterbium.

16
17 30. Apparatus according to any one of the preceding claims and which is in
18 the form of an amplifier, a laser, a master oscillator power amplifier, a Q-switched
19 laser, a source of amplified spontaneous emission, or a continuous wave laser.

20
21 31. Apparatus according to any one of claims 1 to 30 and which is in the
22 form of a laser for material processing.